



## Application of mesoscale models with wind farm parametrisations in EERA-DTOC

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**Application of mesoscale models with wind farm  
parametrisations in EERA-DTOC**

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Support by

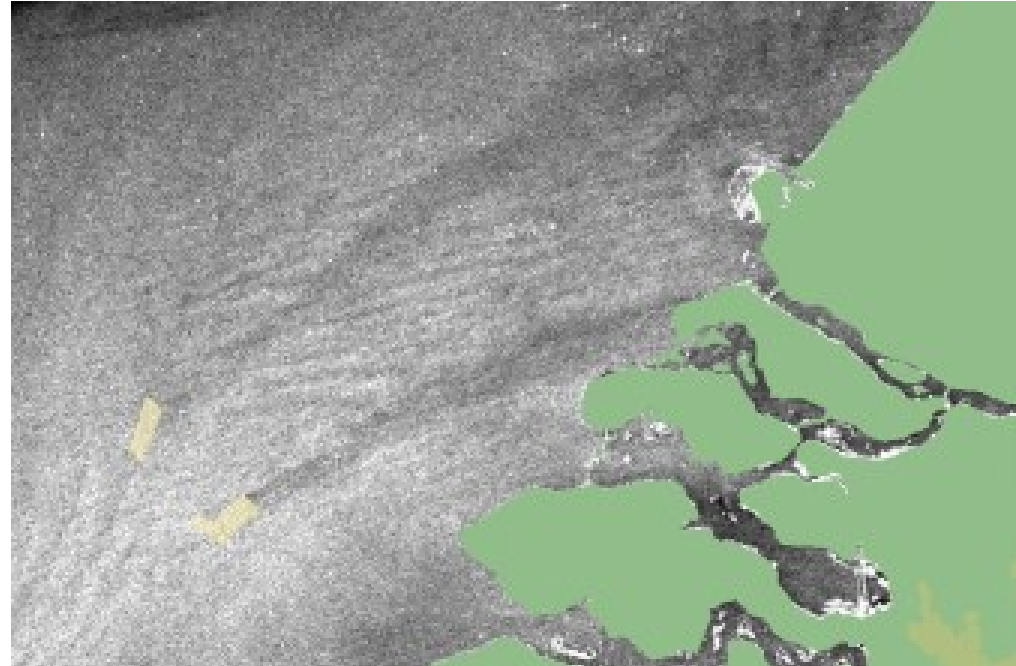


# Introduction

Our aim is to understand better wakes of wind farms, especially their:

- (1) Properties
  - Depth
  - Extension
  - Dynamics
- (2) Long-term impact on
  - Wind resources
  - Environment (T, Q)

Wakes behind Belwind/Thornton



## Content:

- 1) Mesoscale models
- 2) EERA-DTOC Project
- 3) Mesoscale models in EERA-DTOC

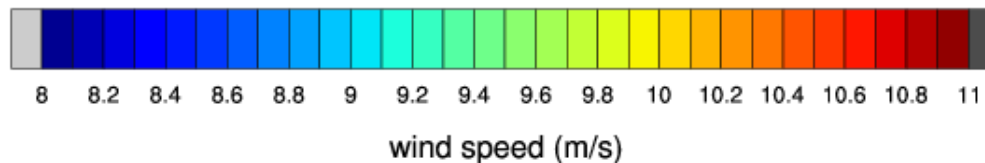
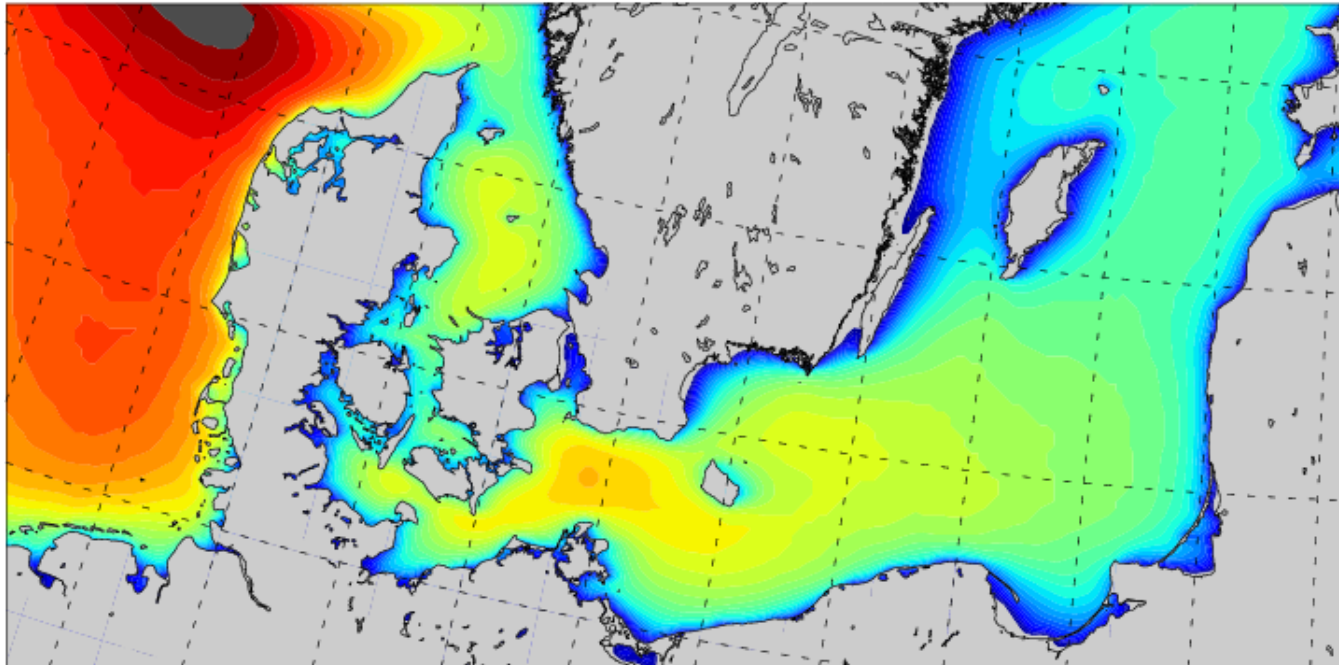
# Mesoscale Model (General)

Mesoscale models are used for:

- Forecasting the weather
- Wind resource assessment

Mean Wind Speed, 2006/05-2007/04

Height: 100 meters



**Weather Research and Forecast model (WRF)**

**2.750.000 Cells for an area  $\approx 180.000 \text{ km}^2$**

**On our cluster: 2/3 Days per year on 70 X 20 processors**

# Wind Farm Parametrisations

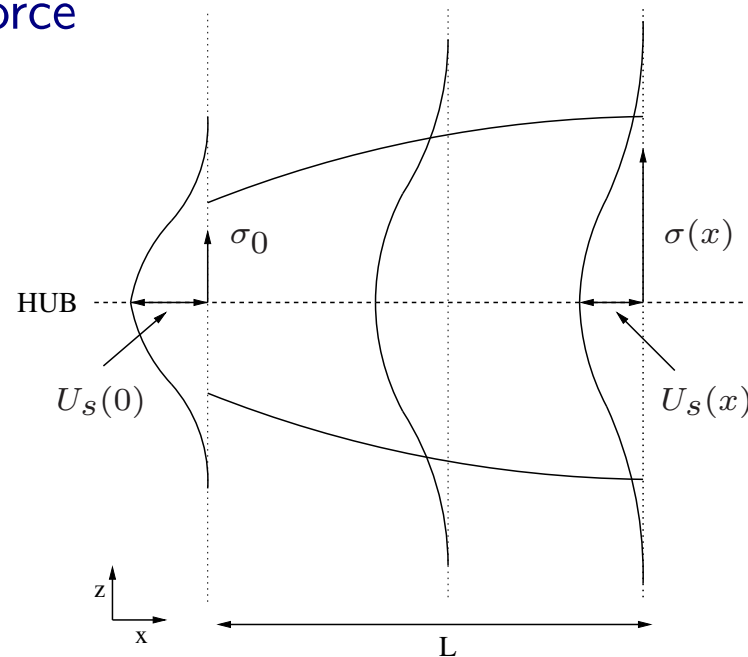
## WRF Wind Farm scheme (Fitch et al. 2012):

- (1) Local drag force (Rotor swept area)
- (2) Additional TKE source term

## Explicit Wake Parametrisation (EWP) approach:

- (1) Accounts for unresolved wake expansion
- (2) Applies Grid-cell averaged drag force

### Concept:



Sketch of the wake development within a grid-cell

**For both schemes the full TKE budget is calculated by PBL-scheme**

# EERA-DTOC Project

EERA-DTOC (Seventh Framework Programme (FP7)):

## European Energy Research Alliance - Design Tool for Offshore Wind Farm Cluster

“Integrated and validated design tool combining state-of-the-art wake, yield and electrical models”

### Universities/Institutes:

- DTU Wind Energy (Denmark)
- ECN (Netherlands)
- Universität Oldenburg (Germany)
- Fraunhofer (Germany)
- CRES (Greece)
- CIEMAT (Spain)
- CENER (Spain)
- CLS (France)

### Industry:

- Carbon Trust (United Kingdom)
- RES (United Kingdom)
- Overspeed (Germany)
- Statoil (Norway)
- Statkraft (Norway)
- Iberdrola (Spain)
- EON (Sweden)

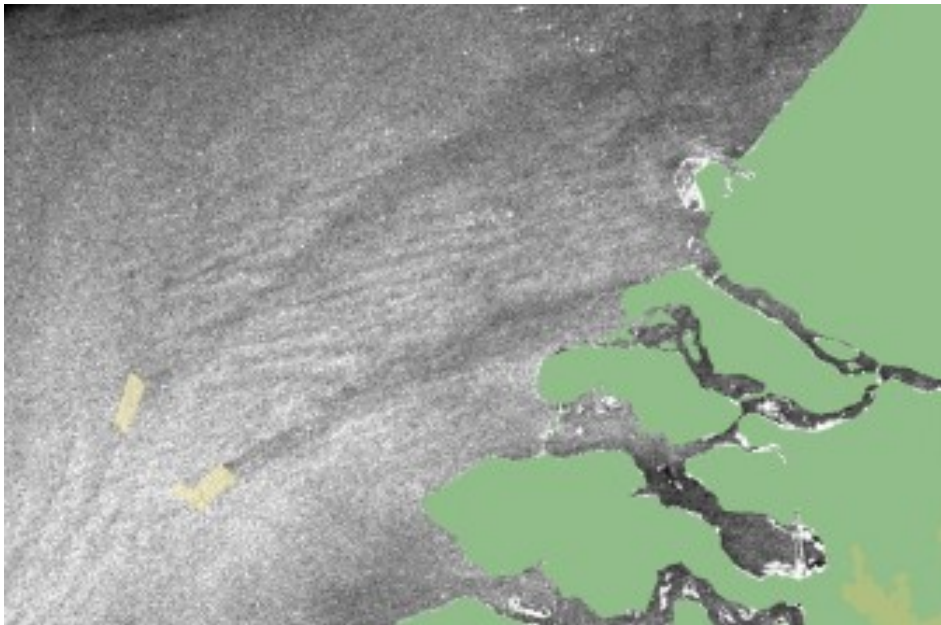


# DTOC - Mesoscale Model Evaluation

Qualitative comparison with Synthetic Aperture Radar (SAR) images. They can retrieve wind speed from back-scatter (higher wind speeds are brighter):

RADARSAT-1/-2 from Data and Products ©MacDonald, Dettewiler and Associates Ltd are acknowledged.

SAR Image (17:34 UTC)



WRF-EWP (17:30 UTC)

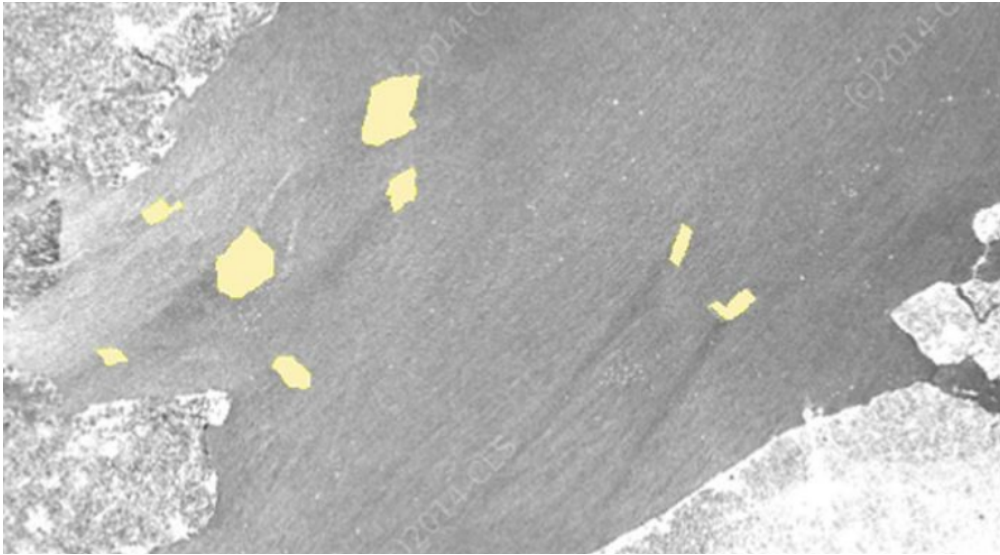


1<sup>st</sup> of July of 2013: Belwind & Thornton

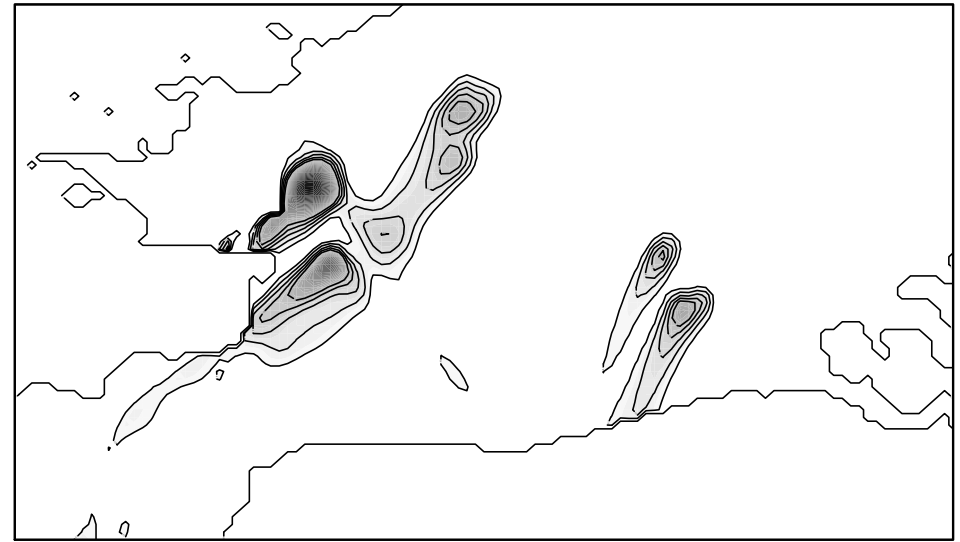
⇒ Comparable extension and divergence

# DTOC - Mesoscale Model Evaluation (cont'd)

SAR Image (17:41 UTC)



WRF-EWP (18:00 UTC)



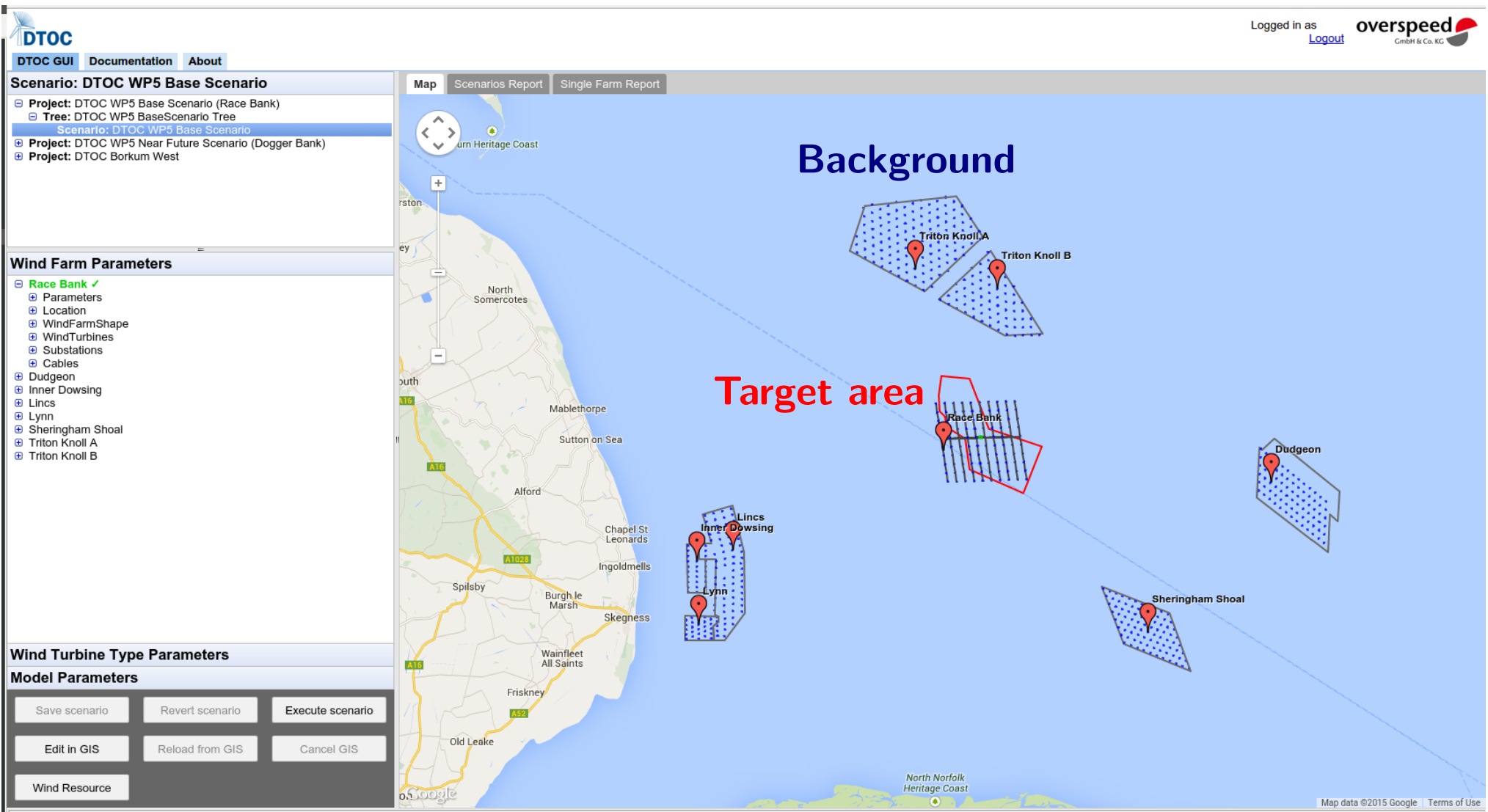
30<sup>th</sup> of April 2013: UK wind farms and Belwind & Thornton

⇒ Challenge in timing snap-shots



# DTOC - User Interface

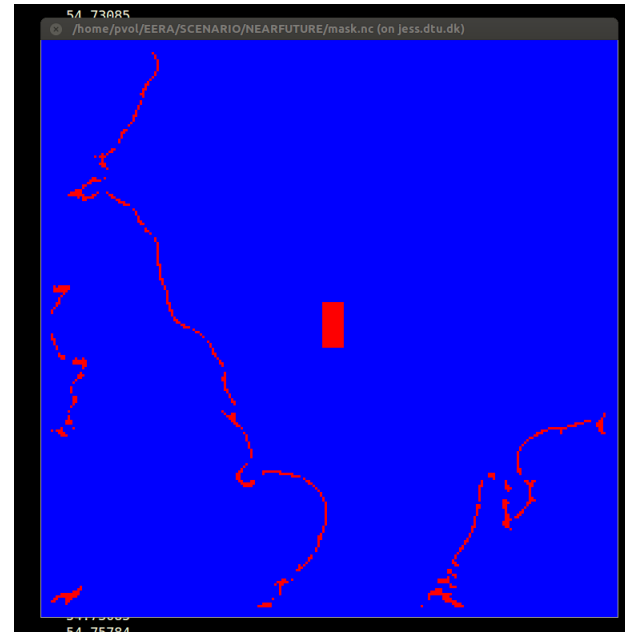
Wind climate in the **target area** from WRF with/without **background** wind farms



**Outcome:** Annual Energy Production of the target wind farm accounting for wake losses of neighbouring wind farms

# DTOC - Mesoscale Model Implementation

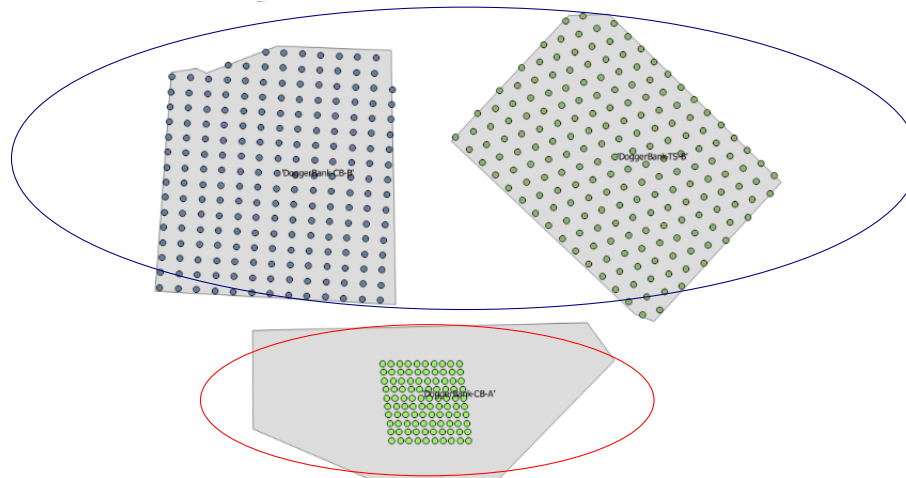
Three institutes (CENER, CIEMAT and DTU) can calculate a Wind Climate for a **target area**



Without and with **background** wind farms

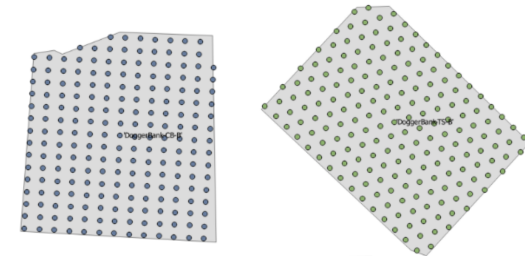
**Background**

**Target area**



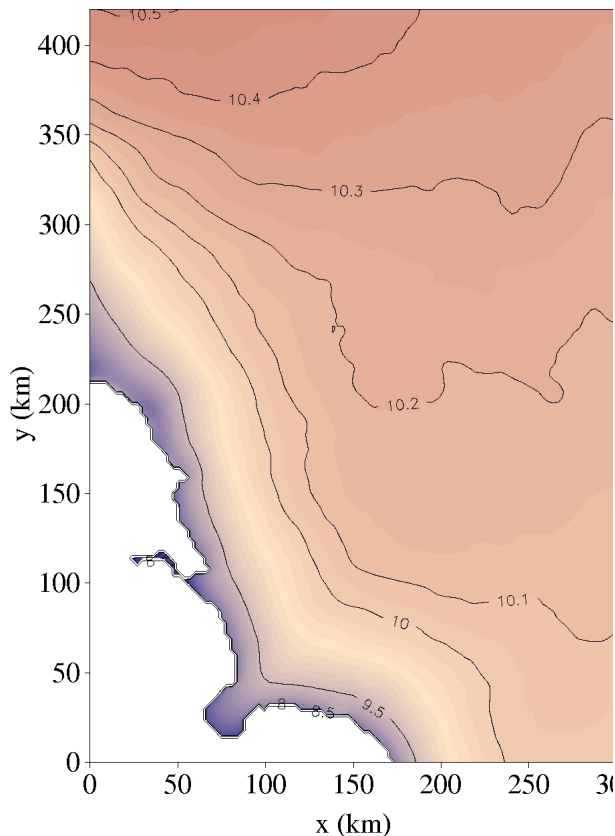
# DTOC - Mesoscale Model Implementation

2 years simulation with WRF-EWP in the North-Sea without/with **background** wind farms

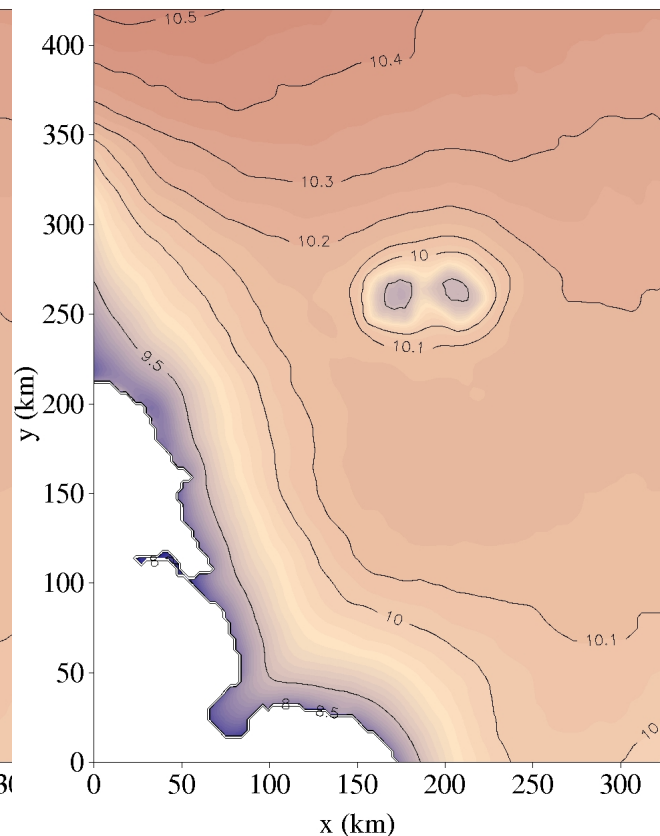


Time averaged wind speed at hub-height (119 m)

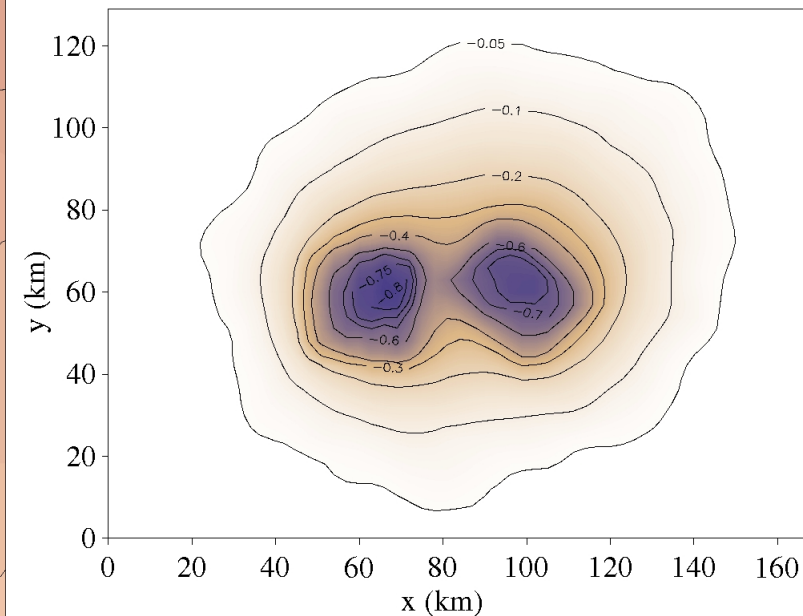
Reference



Wind Farm



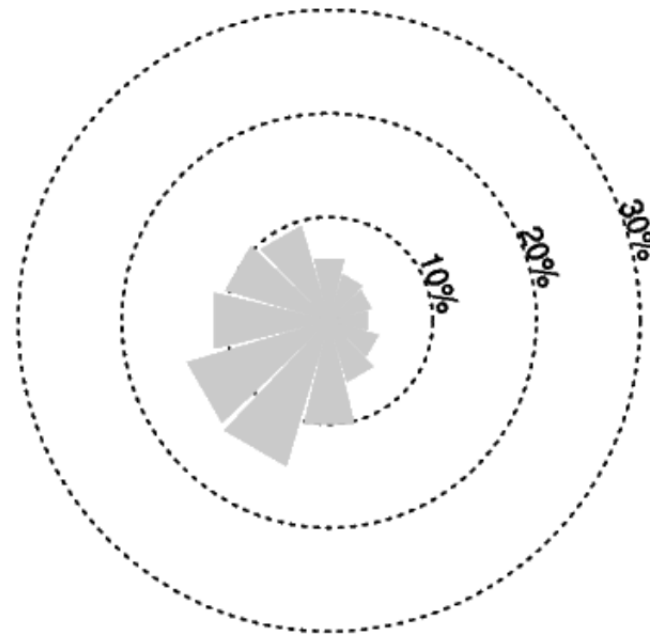
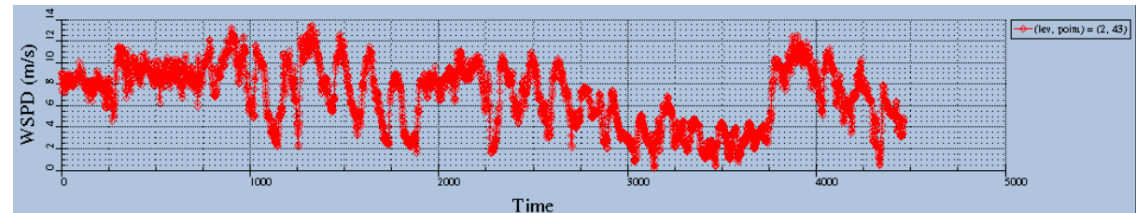
Difference (0.05 – 0.8 m/s)



# DTOC - Mesoscale Model Implementation

The Mesoscale model provides for all point within the **target area** in a given **period**:

- Time-Series
- Modelled Wind Climate
- Generalised Wind Climate (DTU)



# Summary

## Within the EERA-DTOC tool:

- Methodology has been implemented in the DTOC-TOOL
  - Neighbouring wind farms can now be accounted for in time-series and the wind climate
- ⇒ Annual Energy production for a new wind farm for the Wind climate with/without neighbouring wind farms

## Mesoscale models:

- Have the capability to accounts for the dynamics in the wind farm wake
- Further investigation of the long-term velocity reduction is needed

Support by

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